A
PROPOSAL
OF A
NEW METHOD
For finding the
LONGITUDE
At SEA, or LAND.

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A PROPOSAL OF A NEW METHOD For finding the LONGITUDE At SEA, or LAND.

Together with the
Deſcription and Figure of a NEW INSTRUMENT
Invented for the PERFORMANCE of it.

By WILLIAM JONES, M. D.

Nil deſperandum. HOR.
Nihil tam difficile eſt quin quærundo
inveſtigari poſſiet: TER. HEAUT.

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INTRODUCTION.

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NOT to enlarge upon the Utility of knowing the Longitude of Places at Sea, or Land; nor to enter into the various attempts that have been made to come at this diſcovery; it is my deſign in this Introduction only to point out the chief difficulties, that attend this ſearch after the Longitude: and the Methods to be purſued towards the attaining it.

As the Compariſon then of any thing with a well-known thing of the like nature, is as good, and ready a way to come at the knowledge of it's difficulties and defects as any other; let us compare the finding the Longitude at Sea to the finding the Latitude at the ſame place. The Latitude is the neareſt diſtance of any place from the Equator; and to find this, we have certain Marks and Rules to go by: We have the Declination of the Sun, or it's true diſtance from the

Equator, given us in exact Tables for that purpoſe on any, or every certain Day; we have further a pretty true Horiſon offered to our View; and moreover we have very proper and uſeful Inſtruments to obſerve, and find the Sun's greateſt Altitude from this Horiſon; which, computed with the Sun's Declination on any certain day, diſcovers to us the Latitude of the place with ſufficient accuracy, though not with preciſeneſs. The Latitude may likewiſe be found in ſome meaſure by an Obſervation of the fixed Stars; but then we meet with ſuch inaccuracy of the Horiſon from the obſcurity of the night, as renders the ſought Latitude much more uncertain than in the former proceſs.

But the caſe is not ſo well circumſtanced in relation to the Longitude. The Longitude is the Diſtance between two Meridians. In ſeeking for this, Navigators find themſelves bewildered, and quite at a loſs; for they have no ſure grounds to proceed upon, nor any certain mark, or fixed point to commence from; or indeed any other way to find out their own proper Meridian at Sea; at leaſt ſuch as may be judged adequate and ſufficient. But the Author with ſubmiſſion hopes to propoſe, and lay down a Method for aſcertaining the proper Meridian at any place, free from moſt of theſe difficulties and inconveniencies; and conſequently fit for finding the Longitude even at Sea, to ſome degree of exactneſs.

Obſervations by the Cœleſtial Bodies have always been looked upon as the ſureſt, and beſt way of coming at this much deſired, and uſeful diſcovery; and indeed all other Methods vague and precarious: upon theſe therefore he forms his Plan, and hopes by the help of a new-invented Inſtrument to compleat the work.

It was before obſerved, that in ſeeking the Longitude at Sea, there was no certain mark, or fixed point to ſet out from, in order to meaſure any diſtance relative thereunto; and it is for this reaſon, becauſe all the Heavenly Bodies have been conſidered as moving together in their Diurnal Revolution, and keeping nearly their reſpective diſtances; ſo that there was no determining what to meaſure from, and hardly by: but I conceive the North Star has been generally overlooked in this Conſideration; this is a certain mark, and in a great meaſure a fixed point, if we except only it's ſmall diſtance from the true Pole, and it's Aberration conſequent thereupon: things at the ſame time well known, and what may be adjuſted, and eaſily ſettled in any computation hereafter; and are mentioned only, that they may not occur as an unforeſeen objection in the ſubſequent Problem: moreover the North Star, under proper regulations, may be ſaid to be the Center of all Meridians; for the true Polar point is ſo, and every one's proper Meridian does interſect, and paſs through it. If then we can appropriate this Star (which is now to be conſidered as a fixt point) to the aſcertaining different Meridians, we ſhall get over one great, and main difficulty in ſeeking the Longitude; which was a certain mark, or fixt point to govern and regulate our obſervations, and to commence any meaſurement from.

And now in order to find ſomething to meaſure by, let us turn our thoughts to the other fixt Stars and Planets, particularly the Moon. The Moon we know to be a very Anomalous Planet, and one that moves ſo much faſter in her annual period than the fixt Stars, that ſhe ſurpaſſes or exceeds them, during every diurnal revolution, about 13 degrees in angular meaſurement, or 52 minutes in Time, more or leſs; the Exceſs not being every day the ſame for plain Aſtronomical reaſons: this Exceſs then (be it what it will) may undoubtedly by ſome means or other be meaſured; and we are in hopes by our new Inſtrument ſo to do it, as will aſcertain any unknown Meridian within the compaſs of half a degree, or 30 Geographical miles.

But before we proceed any farther we muſt here take notice, that the Moon's exact place in the Heavens, and likewiſe her degree of motion, or her Exceſs of motion beyond any certain fixt Star in Meridianal diſtance for one, and every day muſt be known. Theſe are Poſtulata in this Scheme I confeſs, and neceſſary to the execution of it; but the like was required, and given in finding the Latitude, which was the exact place of the Sun, or his Declination northward or ſouthward from the Equator. Tables were always given of this by the Aſtronomers; and the Moon's place muſt be expected from them likewiſe; nay, with greater reaſon, as this is a much more difficult taſk to be performed than that; ſince it is agreed on all hands that the Moon is ſo irregular in her Motion, that ſhe will not always be found exactly in the place expected; and therefore it cannot be determinately defined by any Rule, or Calculation, but will want to be corrected, and amended by a Series of Obſervations. This difficulty has been long foreſeen, and the means of ſurmounting it ſought after and purſued: for Dr. *Edmund Halley* in the Year 1731 tells us, that when he was appointed Aſtronomical Obſerver by his Majeſty King *George the Firſt*, he was expreſsly commanded *to apply himſelf with the utmoſt care and diligence to the rectifying the Tables of the motions of the Heavens, and the places of the fixed Stars, in order to* *find out the ſo much deſired Longitude at Sea for the perfecting the Art of Navigation.* And he tells us likewiſe, that during his continuance in that Poſt he had made ſo good progreſs, that *he preſumed he was able to compute the true place of the Moon with certainty within the compaſs of two minutes of her motion for the future.* Ever ſince the deceaſe of Dr. *Halley* the Rev. Dr. *Bradley* has enjoyed that Poſt; and it is preſumed, has followed the Steps of his Predeceſſor with the like care and diligence: ſo that we may with great reaſon hope for, and expect accurate Tables of theſe things whenſoever they are wanted, and required for ſuch purpoſes. The Method now propoſed for finding the Longitude is imperfect, I own, without this Knowledge, or ſuch Tables; and at the ſame time confeſs myſelf unable to make them, or furniſh the Publick with them: but give me leave to obſerve at the ſame time, that this operoſe and difficult taſk cannot well be expected from any private Perſon, when ſo long a Series of Obſervations, and ſuch an Apparatus of proper inſtruments, are requiſite to the compleating them with that accuracy and exactneſs that they ought to be.

Though I underſtand of late, that a very great and curious Aſtronomer, the celebrated Mr. *Mayer* from the Univerſity of *Gottingen*, has by his nice Equations reduced the Lunar Theory to ſuch correctneſs, that theſe Tables will be no longer wanting; but may be eaſily given by him, or others upon his foundations, ſufficiently exact to anſwer all the purpoſes of this Scheme.

But to return to our Compariſon: the Horiſon was mentioned in the next place as one certain Mark, or Point for regulating the obſervation of the Latitude at Sea; and this was taken notice of as very obſcure and inaccurate, eſpecially in the Night, when it would be wanted for an obſervation of the Stars; and by that means even the Latitude rendered uncertain: but our Problem will be free from this difficulty and inconvenience, for we ſhall ſtand in need of no Horiſon at all.

Laſtly, The Inſtruments generally made uſe of for finding the Latitude, were deemed proper and ſufficient for that purpoſe; but are by no means adequate to finding the Longitude: This Dr. *Halley* himſelf was ſenſible of, and ſeems to think, Mr. *Hadley*'s reflecting Quadrant might be brought to anſwer this purpoſe: but we don't find that it has yet been done, and I am apt to think never can be, by that Inſtrument. Therefore ſome other was requiſite to be contrived; and This now

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propoſed by the Author is altogether new, and conſtructed upon ſuch principles, that he conceives it may fulfil the intended purpoſe with the aſſiſtance of a Second Watch. It depends only on theſe principles, *viz.* Direct Viſion, Reflection, and a true Perpendicular poſition; which are common to moſt other Inſtruments of this nature.

DESCRIPTION and USE OF THE INSTRUMENT.

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LET there be two Mirrours *a, a* put into one frame *b b b*, one above the other, and made to turn upon Axes *c c, c c* exactly parallel to one another; and let there be a Perpendicular, or Meridian line *d d* ſtruck with Gold, or black, or made any other way viſible upon each; let there be alſo an Apex *e* fixed at the Top of the upper Mirrour directly over the Perpendicular or Meridian line; and then let there be a proportionate ball of lead *f* faſtened by a braſs rod *g g* to the bottom of the frame directly under the perpendicular line; and further let this Apparatus be put into Gimbolls *h h h h* (as they call it) by a croſs rod *i i*, and made to ſwing in another diſtinct Frame *k k k* in the manner the Azimuth Compaſs commonly does: this laſt mentioned frame is to be held in the hands for obſerving, and the other with the Mirrours will continue perpendicular, notwithſtanding the motion of a Ship, by the force of Gravitation; and there muſt be likewiſe an Eye-Vane *l* placed at the end of two diverging legs *m, m*, made to turn upon upright hinges *n*, *n*, and faſtened to the ſides of the frame, ſo as the Center of the Eye-Vane may always continue in the Meridianal Plane. There may be alſo a Mariner's Compaſs put at a convenient place before the Mirrours, with it's Center coincident with the Meridianal plane, to be made uſe of only in ſome particular cirumſtances.

This Inſtrument was indeed at firſt propoſed to be made with a Spirit-level, faſtened to the upper Mirrour inſtead of the depending weight, in order to keep it in a perpendicular poſture; but the weight ſeems to be the readier, and ſurer way of coming at the end propoſed: therefore either may be made uſe of, as ſhall be found moſt commodious.

The ſeveral parts of this Inſtrument are not neceſſary in one, and the ſame obſervation; but are to be made uſe of in the following manner, *viz.*

Firſt, If the North Star (which is the fixt point I propoſed for regulating the obſervation) has but a little, or midling Elevation, according to the Latitude you are in, then only the upper Mirrour with it's appendages will be requiſite to be uſed; thus, Let the Obſerver, looking through the Eye-Vane, bring the North Star to the top of the Apex (or the Bubble in the Spirit-level directly under it, if that ſhould be made uſe of inſtead of the weight): then the Reflecting Mirrour will be objected South; and conſequently the Perpendicular line made thereupon become a Meridian line; whereby to obſerve by reflection the Star proper for that day's obſervation, and likewiſe the Moon in her turn; whoſe apparent Limb is always to be taken, and allowance made for her Semidiameter afterwards. And here let me take notice of one advantage that attends the turning of the Mirrour upon an Axis; by this means the Star and Moon, although they happen to be very different in Latitude, may be brought alternately to fall cloſe under the Apex, and ſo be within view of the Eye together with the North Star; and thereby prevent any motion of the Eye or Hand to the interruption of the obſervation. Now when the proper Star is found to be upon the Meridian line, and at the ſame time the North Star at the point of the Apex, the Obſerver muſt begin, and note by a Second Watch the exact length of Time from that, to the Moon's coming to, or being upon the ſame Meridian line: and herein he muſt be very careful and exact. And if it ſhould at any time happen, thro' the obſcurity of the night, that this Meridian line is not ſo plainly viſible, as might be wiſhed, this inconvenience may be remedied, by throwing an additional light from candles obliquely upon the Surface of the Glaſs or Mirrour; eſpecially if the Meridian line be made with a braſs or ſilver wire.

Secondly, If the North Star has great Elevation, or is almoſt vertical, it will be difficult to obſerve by the Apex: in this caſe both Mirrours muſt be made uſe of in this manner: Turn the lower one towards an Horiſontal poſture, and the upper one towards a Perpendicular, as you ſhall find moſt convenient for ſeeing the two objects together, *viz.* the North Star, and the proper Star ſet down for Obſervation; as alſo the Moon afterwards in her turn: then look through the Eye-Vane, and bring the North Star by Reflection in the lower Mirrour to the Meridian line thereupon; it will paſs under the lower edge of the upper Mirrour, and ſo come to your Eye; then in the upper Mirrour obſerve the Star and Moon, as in the above directions, keeping the North Star always upon the lower Meridian line carefully.

If the Spirit-level is made uſe of, it will be more convenient in this inſtance to ſhift it to the lower part of the upper Glaſs, that all the Objects may be brought nearer together: and by turning the Glaſſes properly on their Axes, you may bring the North Star, the Bubble, and the other Body ſo near, that the Eye may take them in all at one View, without much, or any motion of it's own; as was obſerved before.

Laſtly, In the Southern Hemiſphere, where no Polar Star appears, that I know of, you may have recourſe to the Mariner's Compaſs; bringing the South point (a proper allowance for the Variation being made by an Index) to coincide with the Meridian line, looking through the Eye-Vane, and proceeding as in the other Methods of obſervation.

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PROBLEM.

To find the Longitude at Sea, or Land.

THE Longitude may be found by the meaſure of the Exceſs of the Moon's annual motion compared with fixt Stars upon the Meridian: which will be moſt eaſily and conveniently done by Time.——By Time is not here meant knowing the exact time of night at Sea (this Method being entirely devoid of that great difficulty) but only the time elapſing between one Body's coming upon the Meridian, and another's: which portion of time a good Second Watch may very well be ſuppoſed to keep, and ſhew to great exactneſs.

The Knowledge of the preciſe Time of night at an unknown place, eſpecially if the Horiſon is obſcure or inaccurate, is almoſt as hard to be attained as the Longitude itſelf; for it depends entirely upon having true Altitudes of the Stars from this Horiſon, which, if they be at all erroneous, will cauſe the knowing of the Time to be much more ſo. All the Methods hitherto propoſed for finding the Longitude either by the Moon, or by the Occultations of the Satellites of Jupiter, have been attended with this difficulty amongſt many others: for they require the exact Time of night to be found for the very Baſis of their Computation; if then the foundation be ſo uncertain and fallible, how can the Superſtructure of the Longitude be firm, and to be depended upon?

But now in order to find the Longitude by this Method, there muſt be a Firſt Meridian ſettled, or a fixed place to reckon, and determine your Longitude from: moreover it muſt be known from Calculation what fixt Star culminates, or comes upon that Meridian together with the Moon on any, or rather every day: and alſo how much the Exceſs of the Moon's motion to the Eaſtward of that Star in right Aſcenſion for that whole Day, or Revolution, is. Theſe things muſt be previouſly known, and inſerted in an Ephemeris or Kalendar for Uſe.

Then in whatſoever place you are at Sea, or Land, and want to know your Longitude from the firſt Meridian: you muſt make an obſervation with the Inſtrument deſcribed above, and find when the proper Star for that day comes to your Meridian; and then by a good Second Watch keep an exact account of the time until the Moon comes to it: which Time bears the ſame proportion to the whole Exceſs in time for that day, as your Longitude does to the whole Circumference of the Globe. For example, Suppoſe the Exceſs for the day to be 48 minutes in time, which reduced into Seconds is 2880, and the Time between the Star's being upon your Meridian, and the Moon's coming thither, found to be 35 Seconds, ſay,

As 2880 is to 35, ſo is 21600 miles, the whole Circumference of the Globe, to the Longitude ſought: which will be 262½ miles upon the Equator, or 4 degrees 22½ minutes.

In the *Britiſh* Channel this 4° 22½′ will be equal to about 174 Geographical miles: this brings the proportion between Geographical miles in the Latitude of the *Britiſh* Channel, and our Time, to about 5 miles to every Second; ſo that there muſt be an Error of at leaſt ſix ſeconds in an Obſervation of what is called an Inſtantaneous appearance, to cauſe a Miſtake of 30 miles in the Longitude there.

And give me leave to obſerve, that although the Moon's place ought to be defined as accurately as poſſible, yet a ſmall Error in this particular will not be of ſo much conſequence as may be imagined. Eight or ten Seconds may be looked upon as no ſmall Error in the Moon's place, yet this in the example ſet down above would not amount to one Mile in the Longitude. Nay, even in the diſtance of the *Weſt Indies*, or 60 degrees of Longitude, eight Seconds would cauſe a miſtake but of about ten miles.

Let us now conſider the Aberration of the North Star, or it's diſtance Eaſtward or Weſtward from the Pole, and conſequently from the true Meridian (it's diſtance above or below the Pole interferes not with our Obſervations): and I ſee no great reaſon why This ſhould not be allowed for at once in ſettling the Culmination of the Star and Moon at the Firſt Meridian, which we will now ſuppoſe to be fixt at *London*, ſince the obſervations muſt be made by the North Star conſidered as a fixt Point. However this may be duly calculated, and ſet forth in the Kalendar likewiſe for uſe; and then it will be requiſite only to Add, or Subtract the given Aberration from the Longitude found by the Obſervation. That is to ſay, if you are in Longitude weſtward from *London*, and the

North Star has Weſt Aberration, it muſt be added; if Eaſt Aberration, it muſt be ſubtracted from it. And that for this reaſon, becauſe All Meridians paſſing thro' the true Polar point, and the North Star not reſting preciſely in that point, but deviating a little ſometimes on one ſide and ſometimes on the other, when it is on the Weſt ſide of the Pole, you will arrive at your made Meridian for obſerving the Tranſit of the Star and Moon ſo much ſooner, as that has Weſt Aberration; and *vice verſâ*, ſo much later, as it has Eaſt Aberration: which difference in Time however will be always adequate to the difference of the aberration: and if the given calculation, or meaſurement of the aberration be only properly added, or ſubtracted from the Longitude found by obſervation, it will render the Longitude as true and certain, as if this aberration had not been in the way.

The Meridian line then, that we have all along been laying down, is not an abſolutely true Meridian, becauſe grounded upon a point a little erratick for want of a better; but when ſubjected to this amendment will anſwer the ends and purpoſes of a determined and true one.

This leads me to the conſideration of another ſmall defect in this Scheme, that may be here objected; which is, the motion of the North Star itſelf in it's relative Orbit, (if I may ſo ſpeak) during the time of the Obſervation. This motion will make but a very ſmall difference in moſt caſes; but if in very diſtant Longitudes, it may be thought worth a place in the computation, it muſt be adjuſted, and amended by duly conſidering the place of the North Star in it's Orbit, and it's degree of motion at that time; and then a proper allowance made for it, as in the aberration.

The Objection, that the Moon and Star cannot be ſeen upon the Meridian for ſome nights before, and after her Change, is an objection, that ſo immediately occurs to every one upon the leaſt conſideration, that I had very nearly paſſed it by unnoticed: although it muſt be acknowledged, that during that interval, it is a material one, and almoſt inſuperable. But if we pretend to meaſure by the Moon's motion, upon which this Plan is entirely conſtructed, we muſt acquieſce in the neceſſary, and natural deficiencies of the Moon; and even the accidental ones alſo, without much regret or apology; and comfort ourſelves with the reflection, that in this important affair one good Obſervation, though rare, does abundantly compenſate for many deficiencies: beſides, are we not too ſenſible that the like difficulty often preſſes us in ſeeking the Latitude itſelf, when the weather happens to be dark and cloudy, and the face of the Sun not to be ſeen ſometimes for many days together; and yet this Proceſs ſtands unreproved, nay deſervedly in the higheſt honour and eſtimation.

No other Inſtrument hitherto invented or improved, has been found ſufficient to determine preciſely enough the time of a Star or the Moon's being upon an Obſerver's Meridian at Sea, for this reaſon; becauſe they have depended chiefly, if not altogether, upon the greateſt Altitude for the Meridian, which is liable to ſo many uncertainties and errors: for inſtance, the deceitfulneſs of the Horiſon, eſpecially in the night when this is required; and the near approach of the Curve of the Orbit of Revolution to a ſtrait Line; inſomuch that it cannot be ſaid a Body is at it's greateſt height, till it is found to have deſcended again, and when the Curve and ſtrait line come ſo near Paralleliſm as they do at the Summit, it will take ſome conſiderable time in determining this. But our new Inſtrument is free from theſe inconveniencies, not requiring either Horiſon or Altitudes for aſcertaining the Meridian; but depending on a Tranſit, or Right Aſcenſional meaſurement, and not Altitudinal: therefore I conceive much better adapted to this purpoſe. Let it be farther remarked, that this Obſervation may be made by any other Star, in like manner,

ner, as by the proper Star for the day; provided the intermediate elapſing time be duly kept; for the difference between theſe two Stars in right Aſcenſion may be eaſily thrown off and adjuſted in the computation: and it ſhould ſeem more prudent to lay hold of any remarkable Star, that is not at too great a diſtance, to ground the obſervation upon; leſt the proper Star ſhould not happen to be viſible juſt upon the Meridian, from the interpoſition of an accidental cloud; for the Moon may often be taken very accurately, when a ſmall Star cannot be ſeen at that time.

The Longitude ſhould be reckoned Weſt from the firſt Meridian, or *London*, to avoid perplexity; and the Artificial day of Obſervation ſhould not begin, till the Star and Moon have reached the Meridian of *London*: for if, in what is commonly called Eaſt Longitude, you obſerve by this Star, as you may do, taking the diſtance of the Moon in her approach towards it; it is not to be looked upon as the proper Star for that day, although found ſo in the Kalendar with reſpect to the natural day; but it is the *Terminus ad quem*, and the Obſervation ſhould rather have commenced from the preceding Star, ſet down for the day before; becauſe the Heavenly Bodies have not yet compleated that day's revolution from the firſt Meridian to you in Eaſt Longitude.

[Upon this depends the Paradox of gaining or loſing a day in ſailing round the Globe; for inſtance, If two Ships ſet out from *London* on the firſt of *January*, one keeping an Eaſtward courſe, the other a Weſtward; when they meet again at the place of their departure the firſt of *January* following, he that ſailed to the Eaſtward will anticipate the Time, and call his day of arrival the ſecond of *January*: whilſt the other, that ſailed to the Weſtward, will poſt-date his, and ſay, that it is but the thirty-firſt of *December*; and ſtill both keep a right computation of their own Times.]

Here let me take the opportunity of mentioning, and laying ſome Streſs on a very peculiar, and ſignal advantage that attends this Method above all others; which is, You may prove your Longitude as well as find it: in this manner, When you have meaſured the diſtance of the Moon from the proper, or preceding Star, and noted it; (from whence the Longitude is attained) if you continue the obſervation to the ſubſequent Star, that is, to the Star for the next day, and theſe two meaſurements added together make up the whole Exceſs for the day, or the known diſtance between theſe two Stars in right Aſcenſion, You may be aſſured, and reſt ſatisfied, that your Longitude is true.

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POSTSCRIPT.

IT is now Nine years ago, ſince I firſt drew up, and preſented to the Right Honourable the Earl of *Sandwich*, then firſt Commiſſioner of his Majeſty's Admiralty, a ſhort Propoſal, but like the foregoing, for finding the Longitude at Sea, or Land. A thing of ſo great Utility and Importance, eſpecially to the *Britiſh* nation, that his Lordſhip was pleaſed to receive it with great Courteouſneſs and Approbation; and aſſured me of his Patronage and Favour in the Proſecution of it. But with great Humility and Candour not thinking himſelf ſo competent a Judge in this caſe, as to ſummon a Board of Commiſſioners of Longitude upon it, he immediately ſent the Propoſal, together with a Model of the Inſtrument invented for the performance of it, to the Rev. Dr. *Bradley* and *Martin Folkes*, Eſq; for their conſideration and opinion of the Probability of the Scheme. Before they thought proper to return any anſwer, His Majeſty was pleaſed to remove my Lord *Sandwich* from the Head of the Board of Admiralty, and to confer that high Truſt upon the Right Honourable the Lord *Anſon*. It had been according to the beſt of my recollection about three Months, or more, that I had waited for their Anſwer and Opinion upon this ſhort, and I think plain Propoſal; and then indeed I went to my Country ſeat for the Summer ſeaſon; not knowing when their anſwer would be given: at length I had the honour of a Letter from Mr. *Clevland*, Secretary to the Admiralty, of this purport:

SIR, *Admiralty Office, July,* 15, 1751.

MR. *Folkes* and Dr. *Bradley* having informed my Lords Commiſſioners of the Admiralty that they met together upon the ſubject of your Propoſal for finding the Longitude at Sea, and that they have read over your Paper, and ſeen your Inſtrument delivered with the ſame; but that they do not perceive there is any thing new in your Propoſal; nor are they of opinion it is any way practicable to obſerve at Sea with your Inſtrument, or with any other conſtructed upon the ſame Principles, I am ordered to acquaint you therewith, and that their Lordſhips are ſorry your Studies, ſo well calculated for the Publick Good, do not anſwer the End for which you deſigned them.

I am, Sir,

Your moſt Humble Servant,

J. CLEVLAND.

This Anſwer and Opinion not appearing quite explicit and ſatisfactory to me, and my Friends, the influence of their advice, and ſome regard to the Publick Good, together with the natural fondneſs and partiality we are too apt to have towards our own Offspring, have at laſt prevailed upon me to fit it out in this plain manner, and ſend it into the world to try it's fortune over Sea, and Land. But with great deference and ſubmiſſion I muſt beg leave to expoſtulate a little in it's behalf upon this anſwer and opinion of Mr. *Folkes*, and Dr. *Bradley*.

They ſay firſt then, *that they do not perceive there is any thing New in my Propoſal:* this is indeed ſomewhat ſurpriſing; for I have communicated the Scheme to many ingenious, and learned Gentlemen, who might have been looked upon as tolerable Judges, though perhaps not equal to Dr. *Bradley*, and Mr. *Folkes*, and this Objection was never made by any one of them: but on the contrary it has always been accounted a New Invention, and eſteemed worthy to be carried into experiment and trial. But ſince theſe learned Gentlemen are ſuppoſed to know, and do aſſert that they perceive nothing New in it; I can't help thinking they ought at leaſt to have pointed out the Author, and Place, where it is to be found. This would have immediately put a Stop to my proceedings herein, and prevented the Publick this preſent trouble. If they mean that this Scheme may be met with in the works of Sir *Iſaac Newton*, or Dr. *Halley*, or any other of our lateſt, and beſt Aſtronomers, I muſt acknowledge myſelf quite ignorant of it; or otherwiſe cannot agree with them in their Judgment. Dr. *Halley* indeed in his Aſtronomical Tables, ſpeaking of finding the Longitude of places on the Globe, ſays thus:

" Obſervationes huic operi maximè idoneæ, ſunt Ap-
" pulſus Lunæ ad Stellas fixas; vel Diſtantia ejus a fixâ,
" quæ non longè diſtat à Parallelo Latitudinis in quo Lu-
" na tum verſatur; vel denique Lunæ a Sole diſtantiâ in
" primo, vel ultimo menſis quadrante; ex qualibet ha-
" rum Obſervationum, datâ loci ubi illa facta fuerit Lati-
" tudine, Meridiani ignoti a Grenovicenſi diſtantia in-
" veſtigari poteſt. Invento enim tempore, quod Gre-
" novici numerabatur cum obſervatio facta fuit, ex tem-
" porum differentiâ dabitur Meridianorum diſtantia."

The fitteſt Obſervations for this purpoſe are, the Appulſes of the Moon to fixed Stars, or the Moon's diſtance from a fixed Star, which does not differ much from her in Latitude at that time; or laſtly the diſtance of the Moon from the Sun in her firſt, or laſt quarter; from any one of theſe Obſervations the Latitude of the place where the obſervation is made being given, the diſtance of the unknown Meridian from *Greenwich* may be found. For the Time, which was reckoned at *Greenwich* when the obſervation was made, being found out, the diſtance of the Meridians will be known from the difference of the Times.

Here is indeed mention made of the diſtance of the Moon from a fix'd Star, but that is all the reſemblance that I can perceive between the two Propoſals, His, and mine: and whoſoever will give themſelves the trouble of looking farther into them, I am perſuaded, will find ſufficient reaſons to think them not the ſame: for inſtance, Dr. *Halley* requires the Latitude of the place to be given, proceeds altogether upon Altitudinal meaſurements to find even the times required to be known, meets with different refractions, and a long Series of other difficulties, which this Method ſeems to me to be free from. In fine, I muſt do myſelf the Juſtice to ſay thus much, that (be it as it will) I did not ſteal this Propoſal from Dr. *Halley*, or any other; but planned both the Method and Inſtrument myſelf, and imagined them at leaſt to be new. Give me leave to ſay further, that for my part I ſhould have thought it unworthy any Gentleman of Letters or Breeding to have offered to impoſe upon the Lords Commiſſioners of the Admiralty, or the Publick an old

Scheme, had he known it to be ſo: and beſides to what purpoſe could it have been?

In the next place they ſay, that *they are of Opinion it is not any way practicable to obſerve at Sea with my Inſtrument, or with any other conſtructed upon the ſame principles.* This is ſaid indeed, but no Reaſon at all given to ſupport their opinion; nor the leaſt intimation, that they made any Kind of Trial with it themſelves. Therefore to anſwer them with another bare aſſertion, Many perſons converſant in obſervations have ſeen the Inſtrument, and given it as their opinion; that it is practicable to obſerve with it, even at *Sea:* but this is the very point that ought to be ſubjected to Trial; and I make no doubt but it would be found to anſwer the End.

However they ſay only they are of *opinion* it is not practicable at *Sea*; whereas if it ſhould be found practicable at Land, it would be a Diſcovery of no ſmall moment, and advantage; inſomuch that hereby the true Longitudes of all places at Land, as Capes, Iſlands, *&c.* will be aſcertained with great Eaſe, at almoſt all times, and to great exactneſs: which are now in a great meaſure gueſſed at, and ſet down variouſly from the uncertain Journals of Navigators; (except a few indeed that have been ſettled by Eclipſes, and other Aſtronomical obſervations.)

tions.) This uncertainty in the Longitude of places at Land is of great detriment to Navigation; for the real Longitude of the Port, as well as the Navigator's Longitude, ſhould be equally known in order to his ſpeedy and ſafe Arrival there. Whilſt either of theſe remains uncertain, he will be ſtill at a loſs, and in the dark: for what can it avail him to know exactly where he is, if at the ſame time he continues ignorant how far he is to go. Geography therefore, or a true Delineation of the Parts of the Earth, is one principal Part of the Art of Navigation: if then by the means of this Scheme, the true Longitude of Places *at Land* may be eaſily, exactly, and almoſt at all times aſcertained, (the Latitude alſo being rightly found or previouſly known;) Geography will ſoon be brought to the higheſt perfection; and conſequently the Art of Navigation greatly furthered and improved.

P R O B L E M.

To rectify the Horiſon at Sea in taking Altitudes.

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THE Apparent or Viſible Horiſon is various and uncertain from two cauſes: The difference of the Medium through which it is ſeen; and the different Elevation of the Spectator's Eye from the Surface, or Horiſontal plane. If the Air is hazey, or foggy, or any wiſe thicker than ordinary, the View is thereby ſhortened, and the Horiſon brought nearer to the Eye: in the other caſe, the more the Spectator is raiſed, or elevated above the Superficies of the Sea, the more extended becomes the Proſpect, and the Horiſon is removed further from him. Now the Altitude of any Heavenly Body is the diſtance of the Body above the Horiſon, and this is always meaſured and determined by an Angle; one ſide of which Angle ſhould properly be the Horiſontal plane: but the Obſerver's Eye never reſts in that plane, therefore that Side of the Angle is ever ſubject to change and alteration: for inſtance, the Obſerver's Eye is always elevated more or leſs above the true Horiſontal plane, and when he goes about taking the Angle of Altitude, he muſt be determined by the Horiſon, which he ſees:

the Line of Viſion then not being parallel to the true Horiſontal plane, it will interſect it, and conſequently enlarge the Angle of Altitude. In the other caſe, the Obſerver being likewiſe above the Horiſontal plane, (as he always is) the Apparent Horiſon will approach nearer to him through a thicker Medium, and the greater will be the Angle of Altitude: ſo that in both theſe caſes, we ſee that the Altitude of the Heavenly body is rendered greater than it ſhould really be; but it ſtill remains uncertain how much. Now to aſcertain this, or to rectify the Apparent Horiſon is the Thing propoſed; and it may be done by a ſmall addition, or appendage to *Hadley*'s Quadrant. In taking the Altitude of a Body by this Inſtrument, you look through the Eye-Vane, and then through a Glaſs, partly tranſparent, and partly quickſilver'd, to find the apparent Horiſon through the tranſparent Part, and the object reflected in the quickſilver'd part, or Speculum; and when you have brought the Body and Horiſon together by the proper movement of the Inſtrument, the graduated Limb of the Quadrant gives the Angle of Altitude from the Horiſon, but not the abſolute, and real Altitude. To correct this Error then, let another ſmall Speculum be fixed at the ſide of the tranſparent part of the Object glaſs exactly at right Angles with the line of Viſion; in this Speculum you will ſee the Horiſon behind you by Reflection. Now theſe two Horiſons will not coincide and agree, which they would do, if the line of Viſion, or the Eye were in the true Horiſontal plane: but as the Inſtrument is ſomewhat inclined forwards in looking at the fore Horiſon, the Speculum fixed at right angles with the line of Viſion will be ſomewhat inclined likewiſe, and conſequently the back Horiſon reflected in this glaſs will fall below the fore Horiſon ſeen through the tranſparent part of the Object glaſs. The difference then between theſe two Horiſons is the difference between the real and apparent Altitude; and if you only meaſure this difference by the Inſtrument, bringing the Body ſtill down to the reflected Horiſon, and keeping the fore Horiſon in the ſame place of it's glaſs, this meaſurement (be it what it will) being ſubtracted from the Altitude found by the firſt obſervation, will exactly compenſate for the Error in the Horiſon, and render the Altitude true to the Horiſontal plane. The Diametrically oppoſite part indeed of the Horiſon cannot be ſeen in the Speculum, becauſe it is intercepted by the head of the Obſerver; but this inconvenience may be remedied in a great meaſure by inclining this added Speculum a very little laterally; or by obſerving with the left Eye inſtead of the right, which is generally uſed.

Non Nobis.

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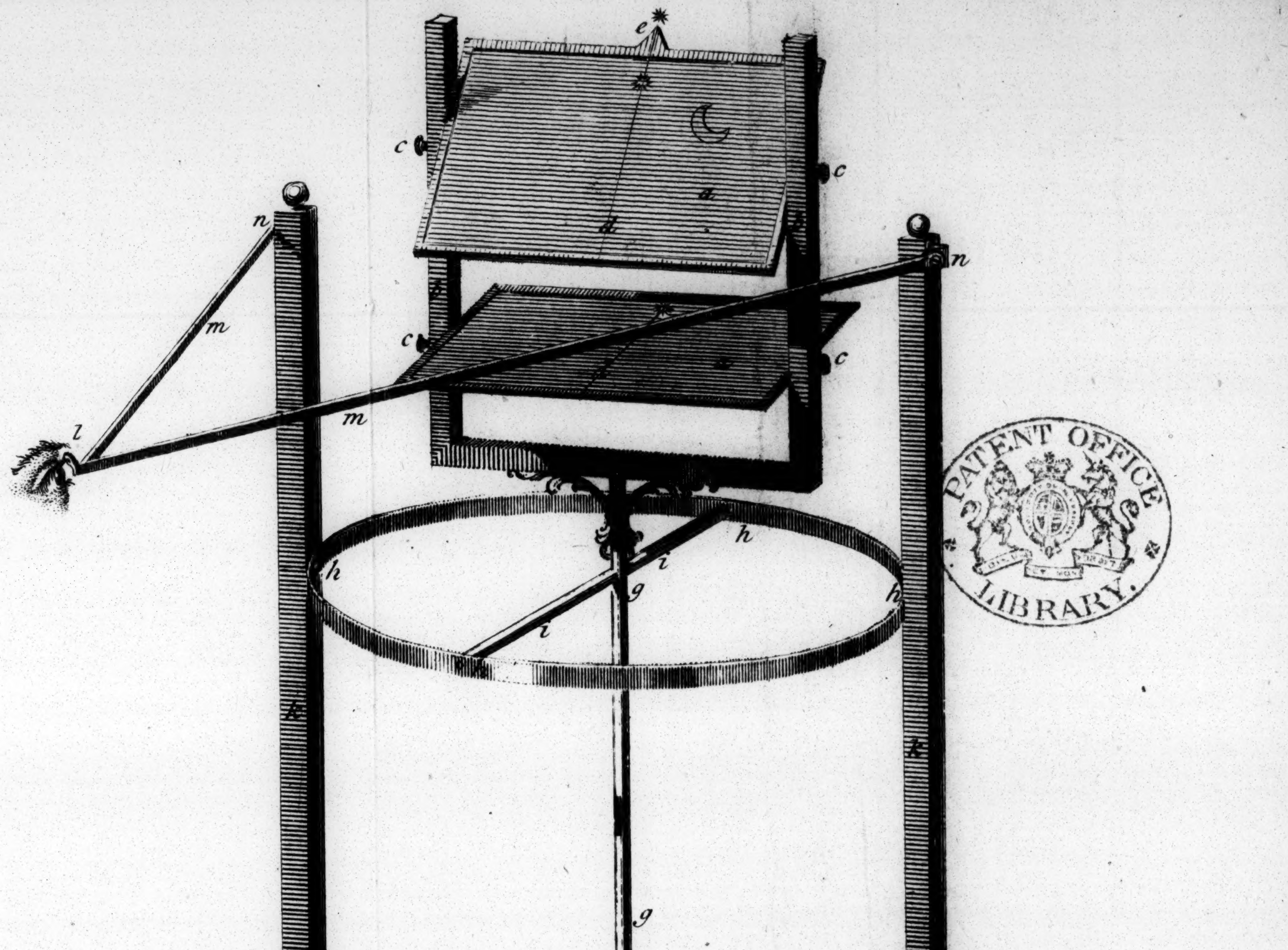

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